COMMUNICATION SYSTEM THAT SHARES PROTECT LINKS

AMONG MULTIPLE SERVICES INCLUDING AN INTERNET SERVICE

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5   RELATED APPLICATIONS

Not applicable

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable

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MICROFICHE APPENDIX

Not applicable

BACKGROUND OF THE INVENTION

15   1. FIELD OF THE INVENTION

The invention is related to the field of communications, and in particular, to the

use of shared protect links for the back-up operations of multiple communication

services.

20   2. DESCRIPTION OF THE PRIOR ART

Internet Protocol (IP) communications systems frequently use IP routers that are

set-up as matched pairs. If one of the IP routers in the pair fails, then the other IP router

in the pair can take over for the failed IP router. In addition, IP routers are connected

over two diverse links. If one of the links between two IP routers fails, then the IP routers use the other link.

Since the IP routers and their links must back each other up, they must retain significant excess capacity to perform their back-up role. Unfortunately, this form of

5   back-up protection requires a serious overbuild in IP links and routers. The overbuild results a excess cost and complexity.

SUMMARY OF THE INVENTION

Some examples of the invention include a communication system comprising: a

10   first Internet Protocol (IP) service node and a second IP service node; a first telephony service node and a second telephony service node; a first optical interface and a second optical interface wherein the first optical interface is coupled to the first IP service node and the first telephony service node and the second optical interface is coupled to the second IP service node and the second telephony service node; a first working link

15   coupling the first optical interface to the second optical interface; a second working link coupling the first optical interface to the second optical interface; and a shared protect link coupling the first optical interface to the second optical interface. The first working link is configured to transfer IP traffic between the first IP service node and the second IP service node. The second working link is configured to transfer telephony traffic between

20   the first telephony service node and the second telephony service node. The shared protect link is configured to transfer IP traffic between the first IP service node and the second IP service node or to transfer telephony traffic between the first telephony service node and the second telephony service node. The first optical interface and the second

optical interface are configured to replace either of the first working link or the second working link with the shared protect link.

In some variations of these examples, the communication system further comprises a first Asynchronous Transfer Mode (ATM) service node and a second ATM service node wherein the first optical interface is coupled to the first ATM service node and the second optical interface is coupled to the second ATM service node; and a third working link coupling the first optical interface to the second optical interface and configured to transfer ATM traffic between the first ATM service node and the second ATM service node. The first optical interface and the second optical interface are configured to replace the third working link with the shared protect link.

In some variations of these examples, the communication system further comprises a first Ethernet service node and a second Ethernet service node wherein the first optical interface is coupled to the first Ethernet service node and the second optical interface is coupled to the second Ethernet service node; and a third working link coupling the first optical interface to the second optical interface and configured to transfer Ethernet traffic between the first Ethernet service node and the second Ethernet service node. The first optical interface and the second optical interface are configured to replace the third working link with the shared protect link.

In some variations of these examples, the communication system further comprises a first frame relay service node and a second frame relay service node wherein the first optical interface is coupled to the first frame relay service node and the second optical interface is coupled to the second frame relay service node; and a third working link coupling the first optical interface to the second optical interface and configured to transfer frame relay traffic between the first frame relay service node and the second

frame relay service node. The first optical interface and the second optical interface are configured to replace the third working link with the shared protect link.

In some variations of these examples, the communication system further comprises a first Storage Area Network (SAN) service node and a second SAN service

5   node wherein the first optical interface is coupled to the first SAN service node and the second optical interface is coupled to the second SAN service node; and a third working link coupling the first optical interface to the second optical interface and configured to transfer SAN traffic between the first SAN service node and the second SAN service node. The first optical interface and the second optical interface are configured to replace

10   the third working link with the shared protect link.

In some variations of these examples, the communication system further comprises a first Multi-Protocol Label Switching (MPLS) service node and a second MPLS service node wherein the first optical interface is coupled to the first MPLS service node and the second optical interface is coupled to the second MPLS service node; and a

15   third working link coupling the first optical interface to the second optical interface and configured to transfer MPLS traffic between the first MPLS service node and the second MPLS service node. The first optical interface and the second optical interface are configured to replace the third working link with the shared protect link.

In some variations of these examples, the first IP service node comprises a first

20   matched IP router pair and the second IP service node comprises a second matched IP router pair.

Some examples of the invention include a communication system comprising: a first Internet Protocol (IP) router and a second IP router wherein the first IP router and the second IP router back-up each other to form a first matched IP router pair; a third IP

router and a fourth IP router wherein the third IP router and the fourth IP router back-up each other to form a second matched IP router pair; a first optical interface and a second optical interface; a first working link coupling the first IP router to the first optical interface; a second working link coupling the second IP router to the first optical

5   interface; a third working link coupling the third IP router to the second optical interface; a fourth working link coupling the fourth IP router to the second optical interface; a fifth working link coupling the first optical interface to the second optical interface; a sixth working link coupling the first optical interface to the second optical interface; a first protect link coupling the first IP router to the first optical interface; a second protect link

10   coupling the second IP router to the first optical interface; a third protect link coupling the third IP router to the second optical interface; a fourth protect link coupling the fourth IP router to the second optical interface; a fifth protect link coupling the first optical interface to the second optical interface; and a sixth protect link coupling the first optical interface to the second optical interface. Under normal operation, the first optical

15   interface connects the first working link to the fifth working link and the second optical interface connects the fifth working link to the third working link to form a first working communication path from the first IP router to the third IP router; and the first optical interface connects the second working link to the sixth working link and the second optical interface connects the sixth working link to the fourth working link to form a

20   second working communication path from the second IP router to the fourth IP router. Under a first back-up operation, the first optical interface connects the first working link or the first protect link to the fifth protect link and the second optical interface connects the fifth protect link to the third working link or the third protect link to form a first protect communication path from the first IP router to the third IP router. Under a second

back-up operation, the first optical interface connects the second working link or the second protect link to the sixth protect link and the second optical interface connects the sixth protect link to the fourth working link or the fourth protect link to form a second protect communication path from the second IP router to the fourth IP router. Under a

5   third back-up operation, the first optical interface connects a first non-IP service link to the fifth protect link and the second optical interface connects the fifth protect link to a second non-IP service link to form a third protect communication path for a non-IP service. Under a fourth back-up operation, the first optical interface connects a third non-IP service link to the sixth protect link and the second optical interface connects the sixth

10   protect link to a fourth non-IP service link to form a fourth protect communication path for a the non-IP service.

In some variations of these examples, the non-IP service comprises telephony service.

In some variations of these examples, the non-IP service comprises asynchronous

15   transfer mode service.

In some variations of these examples, the non-IP service comprises frame relay service.

In some variations of these examples, the non-IP service comprises Ethernet service.

20   In some variations of these examples, the non-IP service comprises storage area network service.

In some variations of these examples, the non-IP service comprises storage area network service.

In some variations of these examples, the non-IP service comprises multi-protocol label switching service.

BRIEF DESCRIPTION OF THE DRAWINGS

5   The same reference number represents the same element on all drawings.

FIG. 1 illustrates a communication system in an example of the prior art.

FIG. 2 illustrates a communication system in an example of the invention.

FIG. 3 illustrates a communication system in an example of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Prior Art Communication System

        A brief discussion of a prior communication system is first provided to facilitate a

5   better understanding of the invention. FIG. 1 illustrates communication system 100 in an

example of the prior art. Communication system 100 includes IP routers 101-104 and

links 111-114. The following table indicates how these elements are linked together.

LINK	ELEMENT	ELEMENT
111	IP ROUTER 101	IP ROUTER 103
112	IP ROUTER 102	IP ROUTER 104
113	IP ROUTER 101	IP ROUTER 103
114	IP ROUTER 102	IP ROUTER 104
115	IP ROUTER 101	IP ROUTER 102
116	IP ROUTER 103	IP ROUTER 104

        IP routers 101-102 back each other up to form matched pair 105, and IP routers

10   103-104 back each other up to form matched pair 106. For example, if IP router 101

fails, other IP routers will stop transferring IP packets to IP router 101 and begin to

transfer IP packets to IP router 102. Likewise, if IP router 102 fails, other IP routers will

stop transferring IP packets to IP router 102 and begin to transfer IP packets to IP router

101.

15   In a similar fashion, links 111 and 113 back each other up, and links 112 and 114

back each other up. For example, if link 111 fails, IP routers 101 and 103 stop

transferring IP packets over link 111 and start transferring IP packets over link 113.

Likewise, if link 113 fails, IP routers 101 and 103 stop transferring IP packets over link

113 and start transferring IP packets over link 111. Typically, links 111 and 113 follow

20   diverse physical paths.

In order to provide this back-up capability, links 111-114 must retain significant excess capacity to handle the load of a failed companion link. Typically, the load of links 111-114 is capped at 40%. Unfortunately, the 40% cap requires many more links than if a higher loading cap is used. For example, a 40% loading cap requires twice as many

5   links as an 80% loading cap. The additional links add undesired cost and complexity to communication system 100. In addition to caps on links 111-114, routers 101-104 are also capped to 40% of capacity provide the excess capacity needed to handle problems. Other equipment may be capped in a similar fashion.

10   New Communication System

FIGS. 2-3 and the following description depict specific examples to teach those skilled in the art how to make and use the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these examples that fall within the

15   scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific examples described below, but only by the claims and their equivalents.

20   Example #1

FIG. 2 illustrates communication system 200 in an example of the invention. Communication system 200 includes IP routers 201-204, optical interfaces 211-212, non-IP service nodes 221-222, and links 241-246, 251-256, and 261-262. The following table indicates how these elements are linked together.

LINK	ELEMENT	ELEMENT
241	IP ROUTER 201	OPTICAL INTERFACE 211
242	IP ROUTER 202	OPTICAL INTERFACE 211
243	IP ROUTER 203	OPTICAL INTERFACE 212
244	IP ROUTER 204	OPTICAL INTERFACE 212
245	OPTICAL INTERFACE 211	OPTICAL INTERFACE 212
246	OPTICAL INTERFACE 211	OPTICAL INTERFACE 212
251	IP ROUTER 201	OPTICAL INTERFACE 211
252	IP ROUTER 202	OPTICAL INTERFACE 211
253	IP ROUTER 203	OPTICAL INTERFACE 212
254	IP ROUTER 204	OPTICAL INTERFACE 212
255	OPTICAL INTERFACE 211	OPTICAL INTERFACE 212
256	OPTICAL INTERFACE 211	OPTICAL INTERFACE 212
261	SERVICE NODE 221	OPTICAL INTERFACE 211
262	SERVICE NODE 222	OPTICAL INTERFACE 212
271	IP ROUTER 201	IP ROUTER 202
272	IP ROUTER 203	IP ROUTER 204

IP routers 201-204 could comprise equipment configured to route IP packets. IP routers 201-202 back each other up to form matched pair 205, and IP routers 203-204

5   back each other up to form matched pair 206. The IP routers in a matched pair each have the same control logic and software so they can take over for the other router in the matched pair. For example, if IP router 201 fails, other IP routers will stop transferring IP packets to IP router 201 and start transferring IP packets to IP router 202. Likewise, if IP router 202 fails, other IP routers will stop transferring IP packets to IP router 202 and

10 start transferring IP packets to IP router 201.

Optical interfaces 211-212 could comprise Synchronous Optical Network (SONET) Add/Drop Mulitplexer (ADM) systems, broadband Digital Cross-connect Systems (DCS), Wave Division Multiplexing (WDM) systems, and optical switching systems. Various combinations and sub-combinations of these systems could be used to

15 form optical interfaces 211-212. Each of the optical interface 211-212 could be distributed among multiple interconnected devices or integrated into a single device. For

example, optical interface 211 could represent a set of SONET cards that are installed in various IP routers and non-IP devices (making links 241-244 and 251-254 internal to the routers and devices). Alternatively, optical interface 211 could comprise a broadband DCS that integrates the functionality of ADM, cross-connect, and WDM systems.

5   Non-IP service nodes 221-222 could comprise Asynchronous Transfer Mode (ATM) systems, digital telephony systems (DS1/ DS3), frame relay systems, Ethernet systems, Storage Area Network (SAN) systems, Multi-Protocol Label Switching (MPLS) systems, or some other communication systems that do not use IP. For example, non-IP service nodes 221-222 could be long distance telephone switches that exchange voice

10   communications over DS3 connections or frame relay switches that exchange data over frame relay connections.

        Links 241-246, 251-256, and 261-262 could comprise optical fibers. Links 241-246 are working links that are used under normal operating conditions. Links 251-256 are protect links that are used under back-up operating conditions. Links 261-262 could

15   be either working or protect links. In some variations, protect links 251-254 could be omitted.

        Under normal operating conditions, working links 241-246 can adequately transfer IP packets between IP routers 201-204. The following table indicates the connections made by optical interfaces 211-212 under normal operating conditions.

OPT. IF	LINK	LINK
211	241	245
211	242	246
212	243	245
212	244	246

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Thus, IP router 201 exchanges IP packets with IP router 203 over a communication path formed by links 241, 245, and 243; and IP router 202 exchanges IP packets with IP router 204 over a communication path formed by links 242, 246, and 244.

Under some back-up conditions, at least one of working links 241-246 can no

5   longer adequately transfer the IP packets. Inadequate packet transfer could mean a total link failure, an excess level of errors on the link, an excess level of latency on the link, or some other measure of inadequate link performance.

If working link 245 can longer no longer adequately transfer the IP packets, then optical interfaces 211-212 change their connections to replace inadequate working link

10   245 with protect link 255 as indicated in the following table.

OPT. IF	LINK	LINK
211	241	255
212	243	255

Thus, IP router 201 exchanges IP packets with IP router 203 over a communication path formed by links 241, 255, and 243. Alternatively, protect link 251 may be used in place of working link 241, either because working link 241 has previously

15   failed and protect link 251 was already being used or because working link 241 is replaced along with failed link 245. In addition and for similar reasons, protect link 253 may be used in place of working link 243. These alternatives are reflected in the following table where IP router 201 exchanges IP packets with IP router 203 over a communication path formed by links 251, 255, and 253.

OPT. IF	LINK	LINK
211	251	255
212	253	255

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If working link 246 can longer no longer adequately transfer the IP packets, then optical interfaces 211-212 change their connections to replace inadequate working link 246 with protect link 256 as indicated in the following table.

OPT. IF	LINK	LINK
211	242	256
212	244	256

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Thus, IP router 202 exchanges IP packets with IP router 204 over a communication path formed by links 242, 256, and 244. Alternatively, protect link 252 may be used in place of working link 242, either because working link 242 has previously failed and protect link 252 was already being used or because working link 242 is

10   replaced along with failed link 246. In addition and for similar reasons, protect link 254 may be used in place of working link 244. These alternatives are reflected in the following table where IP router 202 exchanges IP packets with IP router 204 over a communication path formed by links 252, 256, and 254.

OPT. IF	LINK	LINK
211	252	256
212	254	256

15   Under other back-up conditions, at least one working link (not shown) between non-IP service nodes 221-222 may no longer adequately transfer the non-IP traffic. In this situation, optical interfaces 211-212 may change their connections to replace the inadequate working link with protect link 255 as indicated in the following table.

OPT. IF	LINK	LINK
211	261	255
212	262	255

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Thus, non-IP service node 221 exchanges non-IP traffic with non-IP service node 222 over a communication path formed by links 261, 255, and 262. Alternatively, protect link 256 may be used instead of protect link 255, and as indicated in the following table, non-IP service node 221 exchanges non-IP traffic with non-IP service node 222 over a

5   communication path formed by links 261, 256, and 262.

OPT. IF	LINK	LINK
211	261	256
212	262	256

Example #2

FIG. 3 illustrates communication system 300 in an example of the invention.
10   Communication system 300 includes optical interfaces 315-316, working links 321, and protect links 322. Optical interface 315 is coupled to IP service node 301, ATM service node 303, frame relay service node 305, Ethernet service node 307, telephony service node 309, Storage Area Network (SAN) service node 311, and Multi-Protocol Label Switching (MPLS) service node 313. Optical interface 316 is coupled to IP service node
15   302, ATM service node 304, frame relay service node 306, Ethernet service node 308, telephony service node 310, SAN service node 312, and MPLS service node 314. Optical interface 315 is coupled to optical interface 316 over working links 321 and over protect links 322. Links 321-322 could be configured in a ring, mesh, hybrid, or some other configuration.

20   Under normal operating conditions, optical interfaces 315-316 make connections to connect respective service nodes 301-302, 303-304, 305-306, 307-308, 309-310, 311-312, and 313-314 over working links 321. Note that working links may be fully loaded – for example – to an 80% cap. If one of working links 321 exhibits inadequate